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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Dinesh Kumar SOOD, et al.

Appln. No.: 09/883,220

Confirmation No.: 9834

Filed: June 19, 2001

Attorney Docket No. Q65032

Group Art Unit: 2832

Examiner: Not Assigned

For: BI-STABLE MICROSWITCH INCLUDING MAGNETIC LATCH

SUBMISSION OF PRIORITY DOCUMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Submitted herewith is a certified copy of the priority document on which a claim to priority was made under 35 U.S.C. § 119. The Examiner is respectfully requested to acknowledge receipt of said priority document.

Respectfully submitted,

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Date: December 10, 2001

Q65032
1 of 1

AUSTRALIA

Patent Office
Canberra

I, JONNE YABSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PQ 8247 for a patent by ALCATEL filed on 20 June 2000.

I further certify that pursuant to the provisions of Section 38(1) of the Patents Act 1990 a complete specification was filed on 08 June 2001 and it is an associated application to Provisional Application No. PQ 8247 and has been allocated No. 51823/01.

WITNESS my hand this
Twenty-third day of October 2001

3

J R Yabsley

JONNE YABSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

P/00/009
Regulation 3.2

AUSTRALIA
Patents Act 1990

PROVISIONAL SPECIFICATION

FOR THE INVENTION ENTITLED:

Shape memory

"BI-STABLE MICROSWITCH INCLUDING ~~MAGNETIC LATCH~~"
Alloy Latch. Magnetic Latch

AUSTRALIAN PATENT OFFICE SEC 104

AUSTRALIAN PATENT OFFICE SEC 104

Applicant:

ALCATEL

The invention is described in the following statement:

BI-STABLE MICROSWITCH INCLUDING MAGNETIC LATCH

The present invention relates generally to microswitch arrays and microswitch array elements for switching electrical signal lines. The invention is applicable to the switching of telecommunications signal lines and it will be convenient to hereinafter describe the invention in relation to that exemplary, non limiting application.

Switching arrays are used in telecommunication applications, when a large number of telecommunication signal lines are required to be switched. Generally, such switching arrays are provided by the permanent connection of copper pairs to "pillars" or underground boxes, requiring a technician to travel to the site of the box to change a connection.

In order to remotely alter the copper pair connections at the box without the need for a technician to travel to the site, there have been proposed switching arrays consisting of individual electro mechanical relays wired to printed circuit boards. However, this type of array is complex, requires the addition of various control modules and occupies a considerable amount of space. Further, current must be continuously provided through the relay coil in order to maintain the state of the relay. Since in many applications switching arrays elements are only rarely required to be switched, this results in an undesired power consumption.

It would therefore be desirable to provide a switching array and switching array element which ameliorates or overcomes one or more of the problems of known switching arrays.

It would also be desirable to provide a bi-stable broad band electrically transparent switching array and switching array element adapted to meet the needs of modern telecommunications signal switching.

It would also be desirable to provide a switching array and switching array element that facilitates the remotely controllable, low power bi-stable switching of telecommunication signal lines.

With this in mind, one aspect of the present invention provides a bi-stable microswitch including a pair of contacts and an armature movable between a first

position and a second position to selectively break or make the pair of contacts, the armature being latched in the second position by a magnetic path including a permanent magnet and a magnetisable element having a first curie temperature, wherein the armature is resiliently biased towards the first position when latched, and is movable from the second position to the first position upon heating of the magnetisable element to above the first curie temperature.

Conveniently, the armature may include a first section having a first thermal expansion coefficient and a second section having a second thermal expansion coefficient causing movement of the armature from the first position to the second position upon heating of the armature. Such an armature is known as a thermal bimorph actuator. As an example of materials suitable for the fabrication of the armature, the first section may be at least partially formed of thermalloy whilst the second section may be at least partially formed of invar.

The bi-stable microswitch may further include a first heating device formed on or proximate the armature. A second heating device may also be formed on or proximate the magnetisable element. One or more of the first and second heating devices may include an electrical resistance element.

Alternatively, heat may be applied to at least one of the armature and the magnetisable element by means of electromagnetic radiation. For example, microwave or other radiation may be applied by non-contact means from a remote location.

The magnetisable element may be at least partially formed from a NiCu alloy, such as thermalloy, the composition of the alloy being adjusted to set the first curie temperature.

Conveniently, the permanent magnet may be at least partially constituted by the pair of contacts. The pair of contacts may be formed in or on an electrically isolating substrate. The magnetisable element may be formed in the substrate, and separated from the pair of contacts by an electrically isolating layer formed in or on the substrate. The pair of contacts and the magnetisable layer may be formed by micro machining techniques, involving such steps as etching or electro forming. The armature may comprise a cantilever overhanging the pair of contacts. The

armature may also be formed by micromachining techniques, such as electro forming.

Another aspect of the present invention provides an array of bi-stable microswitches as described hereabove. Each of the microswitches may be at least partly formed in a common substrate by micro machining techniques.

The following description refers in more detail to the various features of the switching array and switching array element of the present invention. To facilitate an understanding of the invention, reference is made in the description to the accompanying drawings where the invention is illustrated in a preferred but non limiting embodiment.

In the drawings:

Figure 1 is a perspective diagram illustrating one embodiment of a bi-stable microswitch according to the present invention;

Figure 2 is a circuit diagram showing the interconnection of two heating elements forming part of the bi-stable microswitch of Figure 1; and

Figure 3 is one embodiment of a switching array including bi-stable microswitches of the type shown in Figure 1.

Referring now to Figure 1, there is shown generally a microswitch 1 formed in an electrically inert substrate 2, such as glass or silicon. Apertures are formed by etching or other micromachining techniques in the substrate 2. Silk screening techniques are then used to apply a slurry of magnetic particles and binding into the apertures formed in the substrate. The orientation of these magnetic particles is then fixed and the slurry set in order to form permanent magnets 3, 4 and 5. The permanent magnets 4 and 5 form a pair of contacts of the microswitch 1. A coating of Au, permalloy or like material is then formed on the upper surfaces of the pair of contacts 4 and 5. It can be seen from Figure 1 that the pair of contacts 4 and 5 project from one surface of the substrate 2.

An insulating dielectric layer 6 is then formed on the other surface of the substrate 2. The dielectric layer 6 may be formed from SiO_2, SiN_2, polyamide or like material. A layer 7 of thermalloy or other magnetisable material is then electro

formed on the dielectric layer 6. The composition of the thermalloy layer 7 is adjusted to set the curie temperature of the layer.

Electrical contacts a" and b" are then formed on the surface of the thermalloy layer 7 and an electrical resistance element 8, such as an NiCr heating coil, is applied to the surface of the thermalloy layer 7 by vapour deposition or like technique.

Electro deposition techniques are then used to form a column 9 and a cantilever 10 of permalloy. A cantilever 11 of invar is then electroformed on the permalloy cantilever 10. An adhesive layer may be applied to the permalloy cantilever 10 prior to the electroforming of the invar cantilever 11.

Contacts a' and b' are then formed on the upper surface of the invar cantilever 11. A heating coil 12 is formed by vapour deposition on the invar cantilever 11.

The heating coils 8 and 12 may be connected in parallel as shown in Figure 2. In this arrangement, diodes 13 and 14 are respectively connected in series with the heating coils 12 and 8 in order that the application of a positive potential difference between common terminals A and B induces the flow of electrical current in only one heating coil at a time, (See Figure 2).

The operation of the bi-stable microswitch 1 will now be explained. Initially the microswitch 1 is in the stable state shown in Figure 1. The microswitch will remain in this state indefinitely until a positive potential difference is applied across the terminals A and B. This causes a current flow I_I through the heating coil 12, causing the temperature in the cantilevers 10 and 11 to rise. The thermalloy cantilever 10 and invar cantilever 11 form two sections, each having a different thermal expansion coefficient from the other, of a same microswitch armature. Such an armature is known as a thermal bimorph actuator.

Due to the different thermal expansion coefficients of its two sections, the heat generated from the heating coil 12 will cause the actuator to deflect downwards until it comes into close proximity with the pair of contacts 4 and 5. This completes a magnetic circuit consisting of the thermalloy/invar actuator, the permanent magnet 3, the thermalloy layer 7 and the pair of contacts 4 and 5. The inclusion of permanently magnetic material in the magnetic circuit will cause the actuator to

latch into contact with the pair of contacts 4 and 5. The pair of contacts 4 and 5 will thus remain indefinitely short-circuited. It should be noted that the pair of contacts 4 and 5 are electrically isolated from the magnetic circuit by the insulating dielectric layer 6.

To release the armature, a negative potential difference is applied between the terminals A and B, thus causing the flow of a current i_2 through the heating coil 8. This heats the thermalloy layer 7. The thermalloy layer 7 is an alloy of NiCu whose curie temperature can be determined by the composition of the alloy. Typically, the curie temperature may be set at approximately 150°C. When the temperature of the thermalloy layer 7 reaches the curie temperature, the permeability of the thermalloy layer 7 drops to unity, thus breaking the magnetic circuit. As a result, the contact latching force drops to a small value insufficient to retain the armature in contact with the pair of contacts 4 and 5. As the armature is not being heating and caused to deflect downwards, the resilient biasing of the armature towards the position shown in Figure 1 causes the armature to return to the stable state shown in that figure.

It will be noted that the bi-stable switch 1 shown in Figure 1 has two stable states with the pair of contacts 4 and 5 being indefinitely open in one state and indefinitely closed in the other state. It does not require the supply of electrical power in either of these two stable states. Electrical power only needs to be provided for a short period, typically a few milliseconds, to cause a transition from one state to the other. Advantageously, the magnetic latching in the closed state results in the microswitch being resistant to vibration, since the magnetic force attracting the actuator to the pair of contacts 4 and 5 increases inversely as any gap therebetween decreases.

Although the embodiment illustrated in Figures 1 and 2 relies upon the use of heating devices formed on or proximate the armature and the layer 7 of magnetisable material, in alternative embodiments heat may be applied to at least one of the these elements by means of electromagnetic radiation or lasers. For example, microwave or other radiation may be applied by non contact means from a remote location.

A microswitch of the type illustrated in Figure 1 can easily be fabricated to have a "foot print" of less than 1 millimetre x 5 millimetres, and is amenable to fabrication using batch processing, standard photolithography, electroforming and other micromachining processes.

Moreover, such micromachining techniques facilitate the fabrication of a microswitch array of elements such as the microswitch illustrated in Figure 1. Figure 3 illustrates one example of a microswitch array 20 including bi-stable microswitch elements 21 to 24 each identical to the microswitch 1 shown in Figure 1. In the example illustrated, control lines 25 and 26 are respectively connected to terminals a and b of the bi-stable microswitch element. Application of a potential difference between the control lines 25 and 26 in the manner described in relation to Figure 2 causes the selective short circuiting of the pair of contacts 27 and 28, thus interconnecting signal lines 29 and 30. Other microswitch elements within the array 20 operate in a functionally equivalent manner.

Finally, it is to be understood that various modifications and/or additions may be made to the microswitch array and microswitch element without departing from the ambit of the present invention described herein.

20 June, 2000

FREEHILLS CARTER SMITH & BEADLE

Patent Attorneys for the Applicant:

ALCATEL

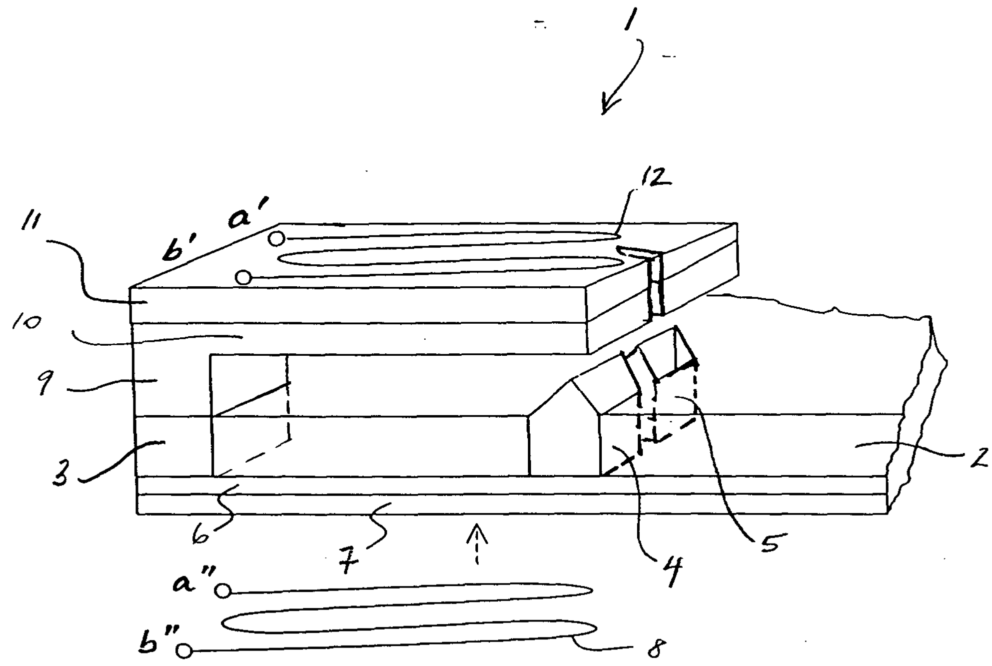

Figure 1

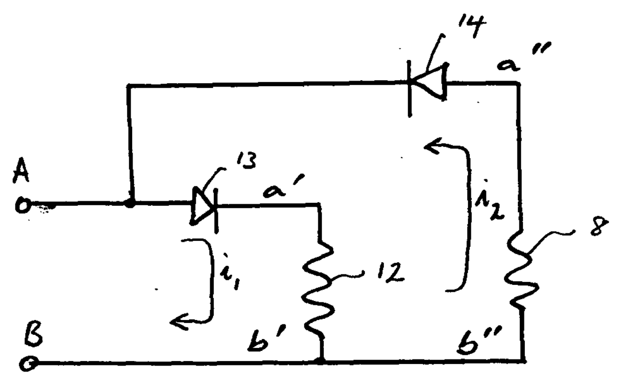

Figure 2

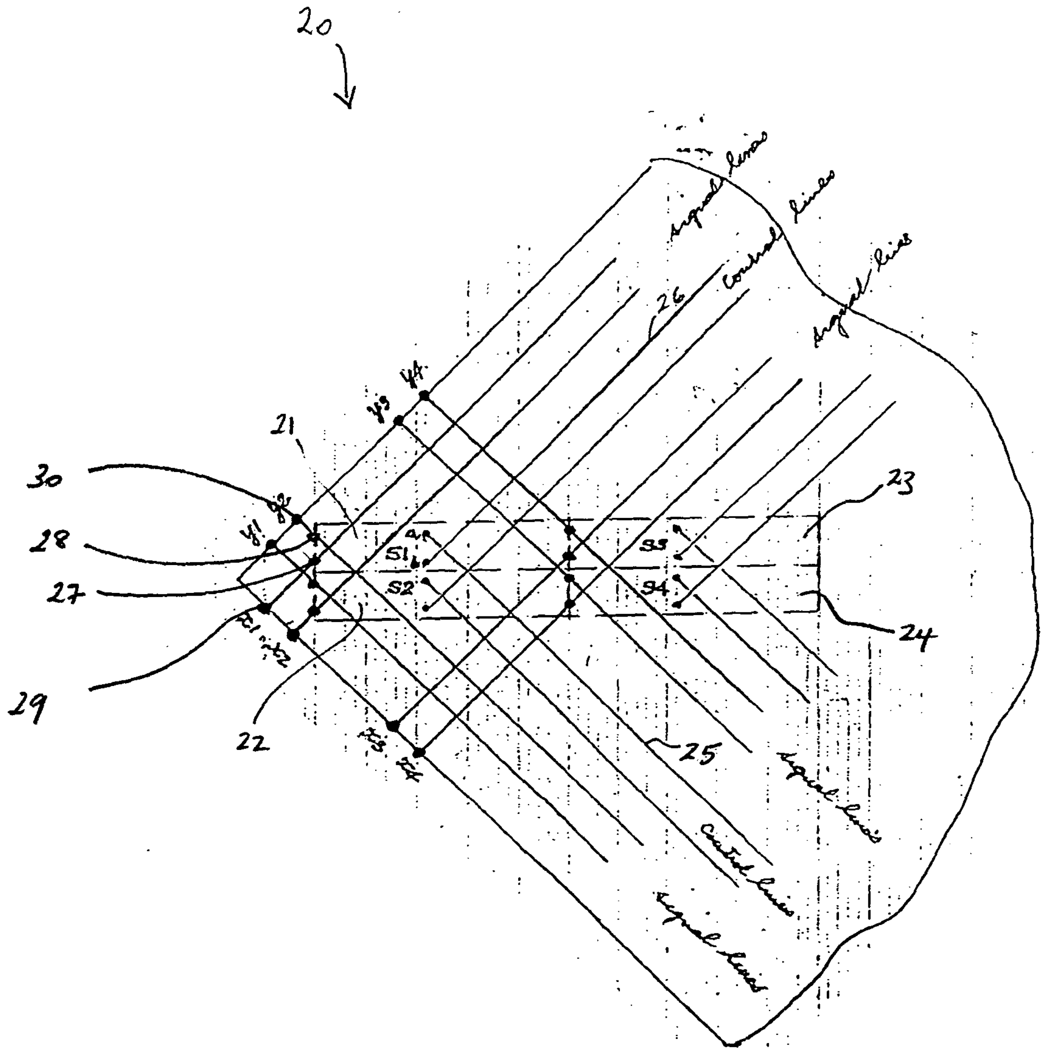
20
signal lines
control lines
signal lines
26
21
30
28
27
29
22
23
24
25
y1
y2
y3
y4
x1
x2
x3
x4
S1
S2
S3
S4
signal lines
control lines
signal lines

Figure 3